# Chapter 11

# INTERSECTIONS

ELEMENTS

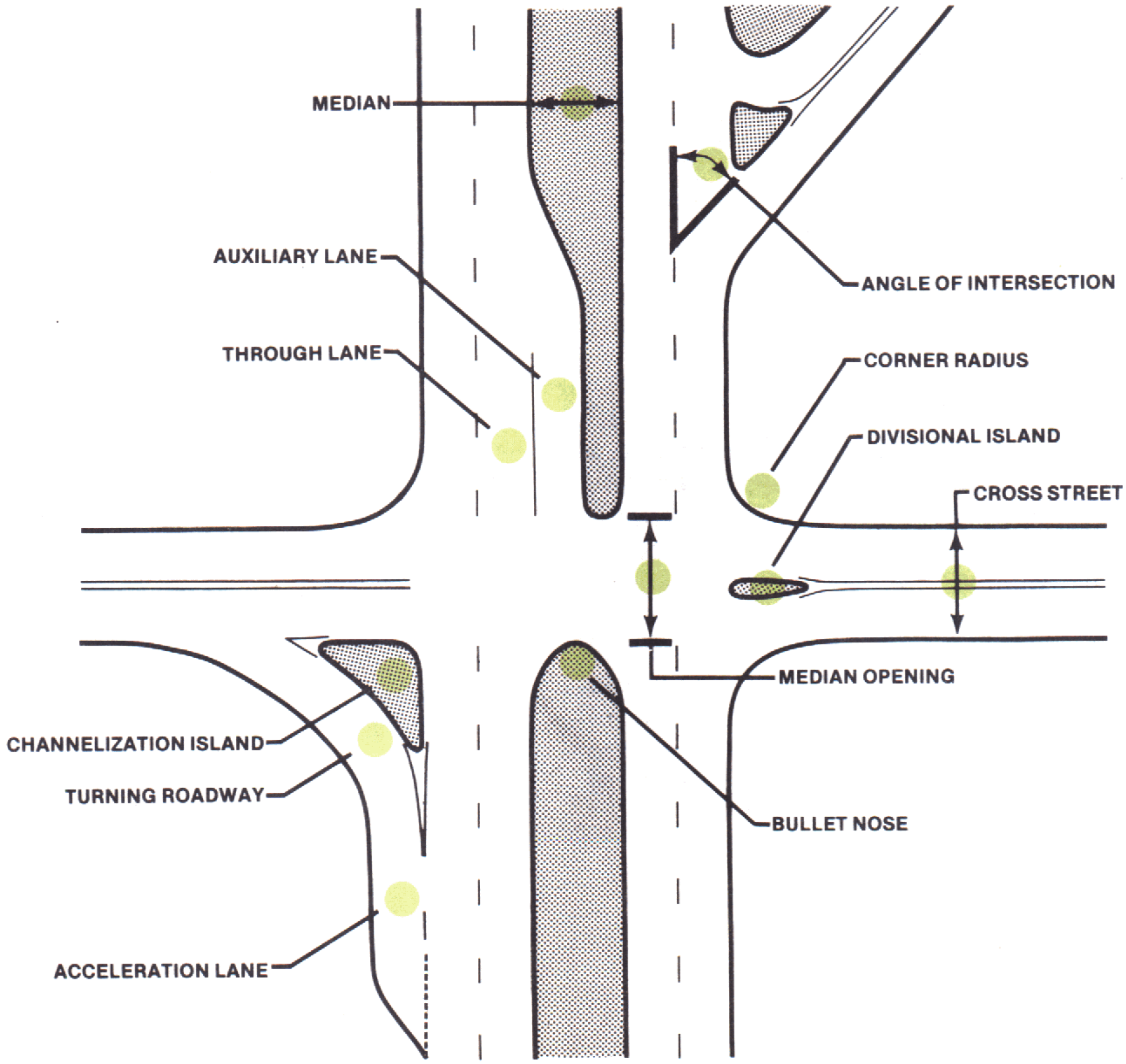
DESIGN

INTERSECTIONS CONTROL CAPACITY AND SAFETY

**THE NUMBER, TYPE, AND SPACING OF INTERSECTIONS determine to a large degree the capacity, speed, and safety of most installation roadways.** This chapter discusses the elements of design as well as various geometric designs that can be used to insure efficient traffic flow. *The selection of the primary geometric and traffic control designs of the intersection are dependent on the traffic pattern during one or more peak traffic periods.*

# ELEMENTS

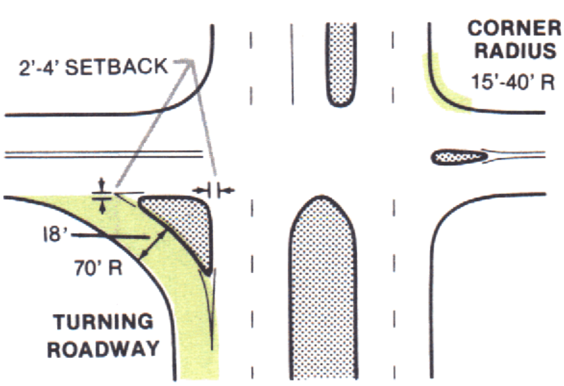
**THE MAJOR ELEMENTS OF INTERSECTIONAL DESIGN are those** *elements that have the greatest impact on vehicle operations, such as medians, channelization islands, deceleration and acceleration lanes, and corner radii.* The dimensions given in this section for those elements are based on widely accepted standards, or are as recommended by the American Association of State Highway and Transportation Officials.



## TURNING ROADWAYS

THE "TURNING ROADWAY" TECHNIQUE *connects two intersection legs.* Thus, *it shortens the travel path for turning vehicles, facilitates traffic control by separating turning movements, and reduces the amount of intersectional pavement by substituting islands for surfaced area.* This technique can also *reduce the frequency and severity of collision between right-turn vehicles and through traffic.* It is warranted, however, only where the main road traffic volume exceeds 10,000 vehicles per day, the road speed exceeds 25 miles per hour, and right-turn maneuvers exceed 30 per hour.

*The critical elements of the turning-roadway design are the island area and location, the turning radius, and the roadway width.* The island must be large enough to command attention and should be located at least 2 to 4 feet from the through lanes. A desirable 90-degree turning lane for buses and single-unit trucks would have a 70-foot radius and an 18-foot width. Angle-of-turn designs for other vehicles may be found in the American Association of State Highway and Transportation Officials publication, *A Policy on Geometric Design of Rural Highways.*




## CORNER RADII

Generally, to the extent practicable, THE CORNER RADII OF INTERSECTIONS ON INSTALLATION ROADWAYS *should satisfy the requirements of the vehicles using the roadways.* However, many **factors** must be considered in **determining the corner radii** of individual intersections, such as: *availability of right-of-way, angle of the intersection, pedestrian use of the intersection, width and number of lanes on intersecting streets, and speed on the roadways.*

Radii of 15 to 25 feet, adequate for passenger vehicles, may be used at minor cross streets with little truck-turning requirement. These small radii may be used also at major intersections with 10-foot-wide parking lanes at the curb and 12-foot-wide travel lanes. At these locations, even semitrailers are able to turn about a 15-foot curb radius with little or no encroachment on adjacent lanes. When using this design, parking must be restricted for at least 30 feet on the approach and 45 feet on the exit. Caution in use of these small radii is advised because traffic volumes may increase to the point where parking will be prohibited and the space used as a travel lane. Where feasible, radii of 30 feet or more should be provided at major cross streets to permit occasional truck turns without too much encroachment.

Where buses and large truck combinations turn frequently, radii of 40 feet or more should be provided. These larger radii are desirable also where speed reductions might cause problems.

## AUXILIARY LANES

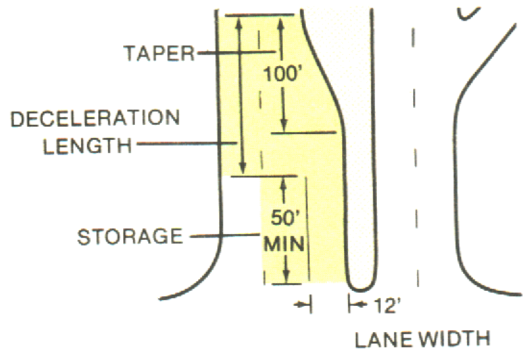
AUXILIARY LANES *are those lanes that adjoin the through travel lanes, but are used to supplement through traffic movement.* These lanes are used primarily as *storage for vehicles turning onto cross streets.* However, they may be used for acceleration of vehicles turning onto the major street, deceleration of vehicles leaving the major street, parking, or as climbing lanes for trucks.

The preferred design width of these lanes is 12 feet, but they may be 10 feet. The length of an auxiliary lane for turning vehicles consists of three components: deceleration length, storage length, and taper length. *The deceleration length is the distance required for a comfortable stop, and generally includes the taper. The storage length is based on the maximum number of vehicles likely to accumulate at any one time.* At unsignalized intersections, design should be based on the number of turning vehicles that arrive in an average 2-minute period within the peak hour. At signalized intersections, storage length should be based on 1.5 to 2 times the average number of vehicles that would store per cycle. In either case, the design length should be on the liberal side to avoid the possibility of through traffic being delayed by a turning vehicle.

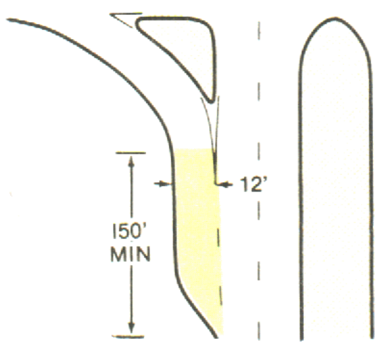
In addition to the deceleration and storage lengths, *the taper length is an important component of the auxiliary lane.* The taper is used in transition from the normal road width to that of the auxiliary lane. For speeds of less than 30 miles per hour, a taper rate of 8:1 is standard and tapers less than 70 feet long generally are unsatisfactory.

*Design for acceleration lanes is similar to that for deceleration lanes,* in that widths and tapers are similar, and the total length of the lane depends on the speed difference between the through traffic and the merging traffic. A minimum length of 150 feet is recommended for these lanes.

**LEFT-TURN DECELERATION LANE**




**ACCELERATION LANE**



| DECELERATION LENGTHS (INCLUDING TAPER) | |
|---|---|
| MAJOR STREET TRAVEL SPEED (mph) | LENGTH (ft) |
| 20 | 160 |
| 30 | 250 |
| 40 | 370 |
| 50 | 500 |

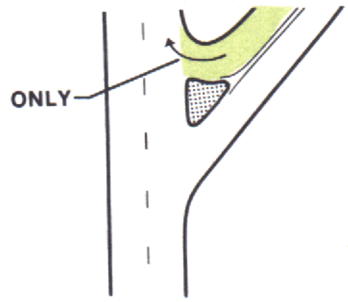
| STORAGE LENGTHS (UNSIGNALIZED)* | |
|---|---|
| LEFT-TURNING VEHICLES (vph) | STORAGE (ft) |
| 30 | 50 |
| 60 | 50 |
| 100 | 75 |
| 200 | 175 |
| 300 | 250 |

*SIGNALIZED — Storage length equals 1.5 to 2 times the average number of vehicles that would store per cycle.

| ACCELERATION LENGTHS (INCLUDING TAPER) | |
|---|---|
| MAJOR STREET TRAVEL SPEED (mph) | LENGTH (ft) |
| 30 | 150 |
| 40 | 310 |
| 50 | 680 |

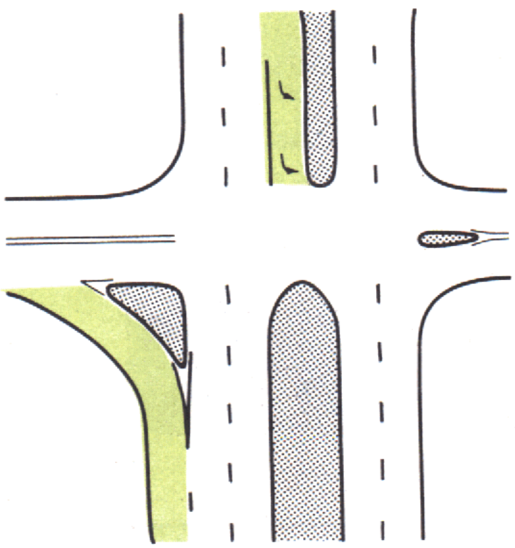
## CHANNELIZATION

CHANNELIZATION *is the design of traffic lanes and islands in a way that will provide definite paths for vehicles to follow within the intersection. Effective channelization reduces the points of conflict in an intersection, or at least reduces the severity of any possible conflict.* In some cases, channelization can prevent wrong decisions and/or reduce the number of decisions the motorist must make. However, if improperly designed, traffic channels and islands can be not only confusing, but also exceedingly dangerous. It must be remembered that, although every intersectional ~~detail~~ may appear vividly in the design plan, the driver sees the intersection at a flat angle. Therefore, if it is too complicated, he may become confused in trying to interpret the intent of the channelization.




CHANNELIZATION

**CHANNELIZATION SEPARATES COMPLEX INTERSECTION MOVEMENTS, AND CLEARLY DEFINES POINTS OF CONFLICT.**



CHANNELIZATION

**CHANNELIZATION REDUCES THE AMOUNT OF PAVED AREA, WHICH DECREASES VEHICLE WANDERING**

**CHANNELIZATION PREVENTS INCORRECT DECISIONS AND CONTROLS THE ANGLE OF CONFLICT**

**CHANNELIZATION FORCES RIGHT ANGLE CONFLICT GIVING MAXIMUM SIGHT DISTANCE**

## CHANNELIZATION DESIGN

- Traffic streams that cross should intersect at or near right angles, unless a merging or weaving maneuver is involved. In those cases, a flat angle of intersection is preferred.

- Points of crossing or conflict should be well separated.

- Refuge areas for turning vehicles should be provided clear of through traffic.

- Prohibited turns should be blocked wherever possible.

- Location of essential control devices should be established as a part of the design of a channelized intersection. Channelization may be desirable to separate the various traffic movements where multiple-phase signals are used.

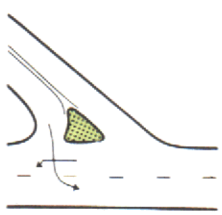
- Channelization islands should be designed so that the vehicle naturally moves through the islands.

- Although the area of vehicle conflict should be reduced as much as possible by channelization, the number of islands should be kept to a minimum. Excessive islands can make it impossible for the driver to determine his or her course of action.

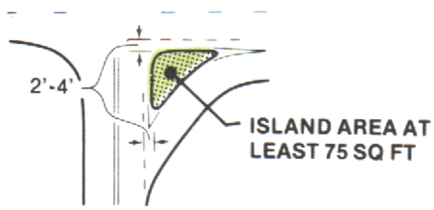
- Traffic islands should be at least 4 to 6 feet wide and at least 12 to 20 feet long. Smaller islands confuse the driver.

- Channelization islands should be set back 2 to 4 feet from the traffic lane so that they do not form an obstruction that tends to cause the vehicle to swerve away from the island.

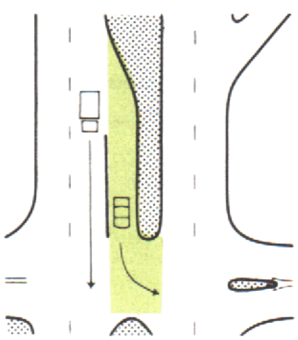
CONTROL ANGLE OF CONFLICT



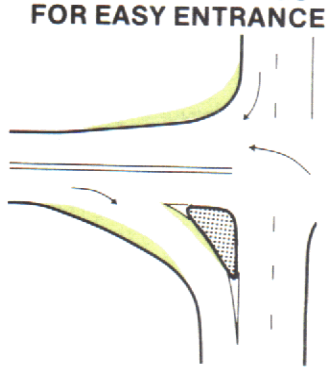
ISLAND SIZE AND LOCATION




PROTECTION AND STORAGE



FLARED OPENINGS FOR EASY ENTRANCE



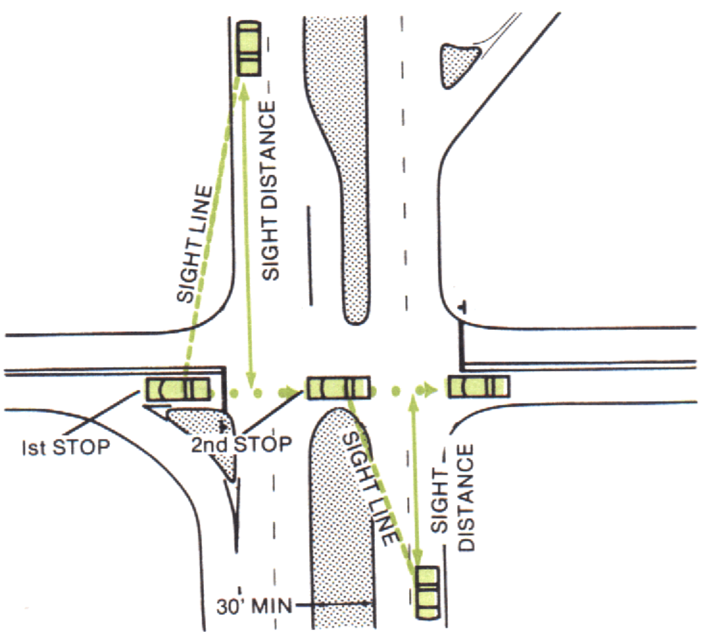
## SIGHT DISTANCE

Along the roads of an intersection, as well as across all road corners, SIGHT SHOULD BE UNOBSTRUCTED FOR A DISTANCE THAT WILL ENABLE DRIVERS APPROACHING THE INTERSECTION TO SEE EACH OTHER IN TIME TO PREVENT COLLISION. The sight distance needed at a given intersection *depends on the type of traffic control at that intersection, width of the road, speed of approach, and type of vehicle.* Where no control exists, sight distance along each intersectional leg must be great enough that a driver can see any obstacle at the intersection in time to avoid it. Where cross-street traffic is controlled by STOP signs, the driver of the stopped vehicle should see enough of the major road to be able to clear the intersection before a vehicle that comes into view after he has started reaches the intersection. This distance is the basic criterion for most roadways. Where sight distance is inadequate, speed zones or signal control may be required for safety.

| STOP CONTROL ON CROSS STREET | | |
|---|---|---|
| DESIGN SPEED (MPH) | REQUIRED SIGHT DISTANCE* | |
| | 2 LANES (FT) | 4 LANES (FT) |
| 30 | 405 | 465 |
| 40 | 540 | 620 |
| 50 | 675 | 775 |
| 60 | 810 | 930 |

*Sight distance for single unit truck.

**For divided roadways, medians equal to or wider than the vehicle length enable the crossing to be made in two steps. Narrower medians should be included in the width to be crossed in one step.**

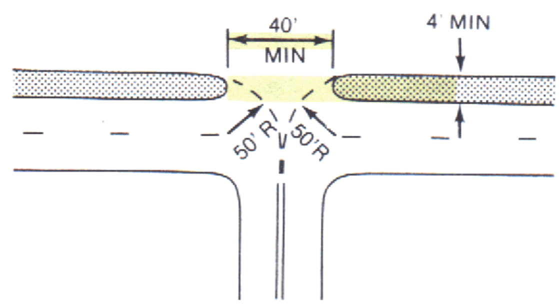


## MEDIAN OPENINGS

**The design of medians** for intersections **depends on the character and volume of through and turning traffic.** Where nearly all vehicles travel through the intersection, and the volume is well below capacity, the simplest and least costly median opening may be adequate. Conversely, where crossing and turning movements are numerous and speeds and traffic volumes are high, the median should be of a shape and width that will permit efficient turning movements.

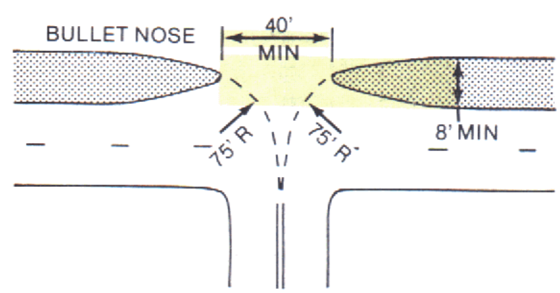
### 1 MINIMUM DESIGN

For medians requiring only a simple design, the length of the median opening and shape of the median end are determined by the vehicle turning radius. The arc of the radius is tangent to the median edge and the centerline of the crossroad. For single-unit trucks and an occasional semitrailer, a 50-foot radius with a semicircular median end is acceptable. The minimum length of the median opening should be at least 40 feet; and the maximum length no more than 100 feet.



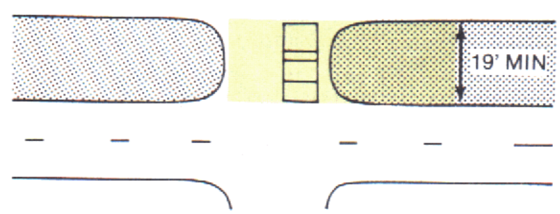

### 2 ABOVE-MINIMUM DESIGN

Where above-minimum designs are required, the general pattern for the simple design is used, but with larger dimensions. For example, in lieu of using a 50-foot control radius for single-unit vehicles, a 75-foot radius could be used. Also, for medians wider than 8 feet, a bullet-nose median end can be used in lieu of the semicircular end. This end treatment improves vehicle travel paths, lessens intersectional pavement, and shortens the length of the median opening.




### 3 DESIGN FOR CROSS TRAFFIC

Where signalization is unjustified and crossing movements are unsafe, the median should be wide enough to store at least one vehicle. The controlling median width is the length of the design vehicle to be accommodated.



# DESIGN

The regulated sharing of common space where two or more roadways intersect requires intersection designs and traffic controls that are drastically different from those of the open road. "INTERSECTION DESIGN" *is the process of determining the best way one traffic stream can cross another or make certain movements without conflict.* For example, where two major roadways cross, some type of bridge structure may be required to eliminate conflict. Where two minor roadways cross, however, traffic conflict may be controlled simply with a stop sign. In general, then, **traffic volume, speed, and accident rate** — *as well as the ever-present economics* — **determine the method to be applied at a given crossing.** This section illustrates various designs that can preclude conflict at roadway crossings.

## CLASSIFICATION

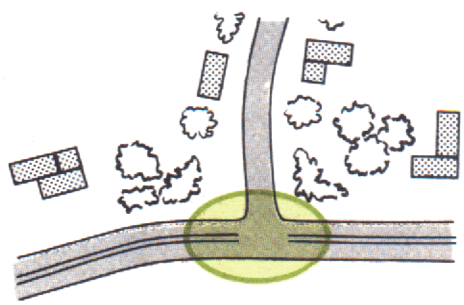
Design requirements for intersections vary with the importance of the intersecting roadways. Therefore, the functional classification used here places *crossing roadways into three groups* in accordance with their importance: *minor/minor, major/minor, and major/major.* Each group carries a set of suggested minimum design standards, which correspond with the importance of the roadway system and the specific service each is expected to provide.

### 1 MINOR/MINOR INTERSECTION

THE INTERSECTION OF TWO LOW-VOLUME ROADS should be kept *simple in geometry and traffic control.* Drivers need only to be able to see other approaching vehicles so as to judge their speed and distance. Design of this intersection should insure that: *paths on approach to and through the intersection are natural; horizontal and vertical alignment is compatible with the operation; and sight distance is sufficient.*

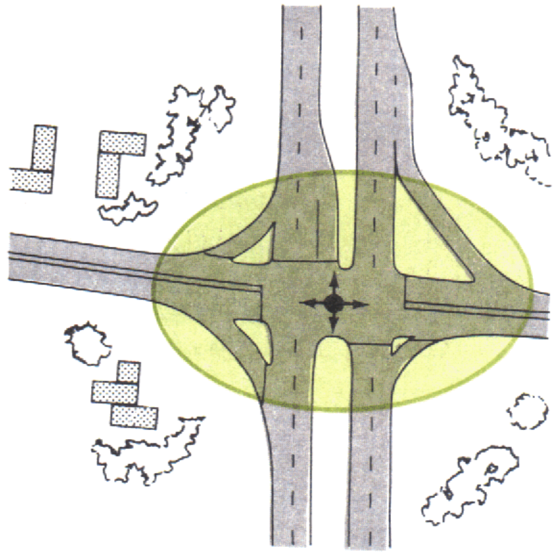
### 2 MAJOR/MINOR INTERSECTION

Where a low *volume road* and *a high volume road* intersect, it is basic that drivers on both roads know immediately which road is major. Also, good sight distance for both roads is essential but particularly for vehicles crossing the major road. Traffic control of these intersections generally is provided with stop signs on the minor road.



## 3 MAJOR/MAJOR INTERSECTION

Heavy traffic volumes where two or more roadways cross each other may require drastic changes from open road operating conditions, and capacity considerations because of the regulated sharing of common space. The configuration of the intersection is the principal determinant of operational safety and efficiency. The type of control and geometry can vary extensively. For example, *control may vary from yield signs to traffic signals, and geometry may vary from a two-lane, two-way roadway to a six-lane divided roadway with auxiliary lanes and turning roadways.* Because of extensive variations that may be required to handle heavy traffic volumes, requirements for both present and future demand should be established prior to design.



### DESIGN REQUIREMENTS

- **Horizontal and vertical alignment should be compatible with operational requirements.**
- **Paths on approach and through intersection should be natural.**
- **Traffic should be separated according to maneuvers.**
- **Turning maneuvers should be physically accommodated.**
- **Turning roadways should be designed for reasonable speeds.**
- **Good transitions to turning roadways and auxiliary lanes should be provided.**
- **Sight distances should be sufficient for conditions.**
- **Design must be compatible with environmental conditions.**

**DRIVERS SHOULD BE ABLE TO:**

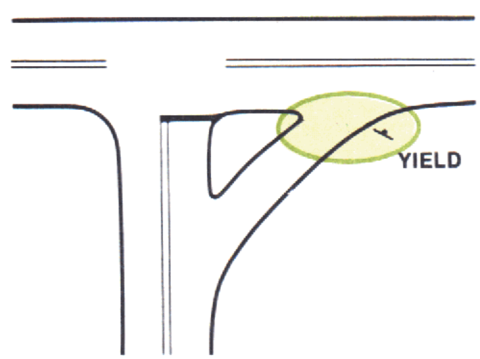
- **DETECT THE IMPORTANCE OF THE INTERSECTING ROADWAY.**
- **DETERMINE THE REQUIRED LANE OR POSITION IN ORDER TO ACCOMPLISH THE INTENDED MANEUVER.**
- **IDENTIFY AND RESPOND TO THE CONTROL DEVICE.**
- **IDENTIFY THE REQUIREMENTS OF THE INTERSECTING TRAFFIC STREAM AND JUDGE THE CHARACTERISTICS OF THAT STREAM AS THEY RELATE TO THE MANEUVER.**

## CONTROL

Many methods may be used to enable one traffic stream to cross another or to make certain turning movements efficiently and safely. However, **basic crossing conflicts can be eliminated by** use of these devices: **yield signs, stop signs, and traffic signals.**

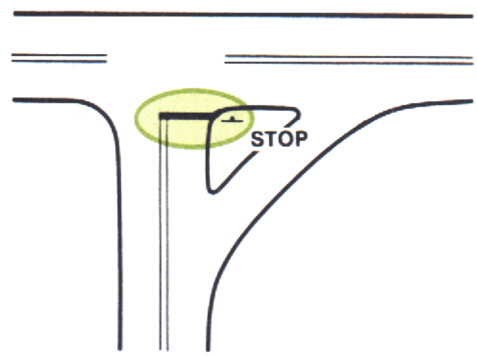
### 1 YIELD SIGNS

YIELD SIGNS generally are *used where minor roads intersect, where traffic speeds are low, and/or where adequate sight distance is available.* The yield sign indicates to the driver that he must decide whether to continue through the intersection at 15 or 20 miles per hour or come to a complete stop. Thus, *sight distance must be sufficient for the driver to look in both directions, determine his course of action, and then either traverse the intersection or come to a complete stop.* This sign should never be used to protect entrances on major streets.



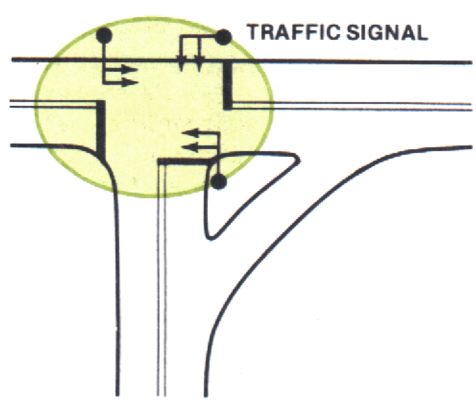
## 2 STOP

At an *intersection of a minor roadway with an intermediate or major one,* the *crossing conflict* generally can be *controlled* by the use of a stop sign. The driver on the minor street must have sufficient sight distance to judge when it is safe to cross and must have an adequate gap in the traffic flow. It is possible to make use of a stop-and-enter crossing only when the traffic volumes on the major facility are not over approximately two-thirds of the capacity of the facility. When the major facility is flowing continuously, it will be difficult, if not impossible, to make a safe crossing. When this condition exists, more restrictive control is required.




## 3 TRAFFIC SIGNAL

The most restrictive intersectional control — *signalization — should be used only at major intersections and, desirably, only where the road speed does not exceed 45 miles per hour.* The signalized intersection should be designed so as not to reduce the capacity of the street system. For example, if two major roadways are to cross at an intersection and each will operate near capacity, the traffic signal may reduce the capacity of both roads to one-half. In this case, additional traffic lanes within 1,000 feet of the intersection may be desirable.

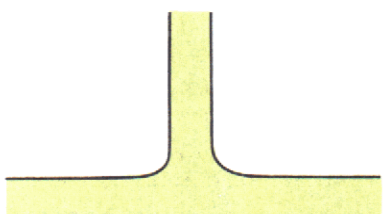


## INTERSECTION TYPES

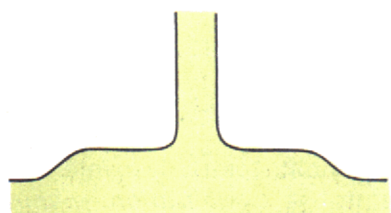
THE BASIC TYPES OF INTERSECTIONS *are determined by the number of intersecting legs;* that is, **three-leg, four-leg, multileg.** However, any one of the basic types **can vary greatly in scope, shape, and channelization.** Once the type is established, a final geometric design can be selected simply by applying the design controls and elements previously discussed. In this section, each type of intersection, with likely variations, is discussed. Traffic control for every type of intersection is not discussed; however, all types of intersections shown lend themselves to control, ranging from yield signs to traffic signals.

### 1 THREE-LEGGED

Generally, this design is *used to terminate one roadway.* Where turning movements are hazardous, the intersection may be flared or designed with turning roadways. A Y-type design, an undesirable version of the T-intersection, generally results in operational problems.

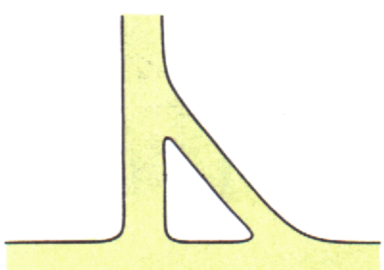


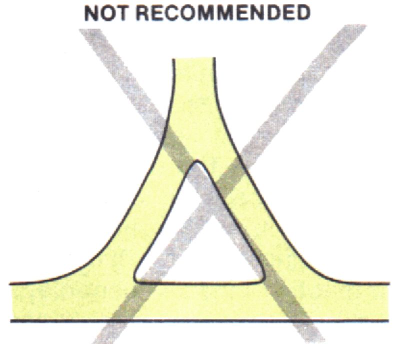
UNCHANNELIZED



FLARED

NOT RECOMMENDED

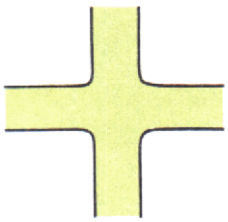




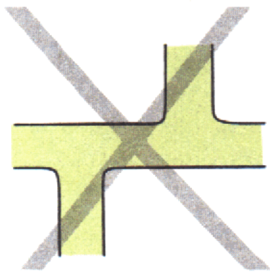
TURNING ROADWAYS

## 2 FOUR-LEGGED

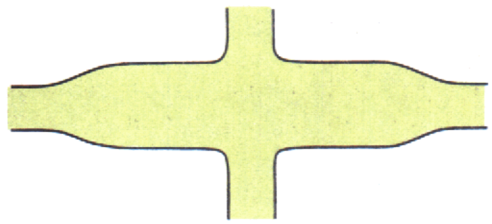
*Except that it provides for the direct crossing movement,* a cross-intersection is *similar to the T-intersection.* The cross-intersection has many variations, depending on operating conditions. The *right-angle* is the common crossroad type; however, the crossroad may be skewed, even though this is undesirable.



UNCHANNELIZED



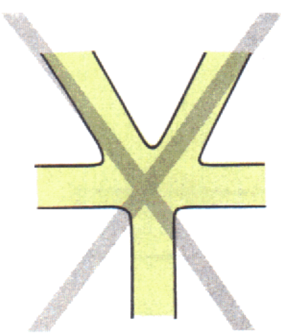
OFFSET
NOT RECOMMENDED



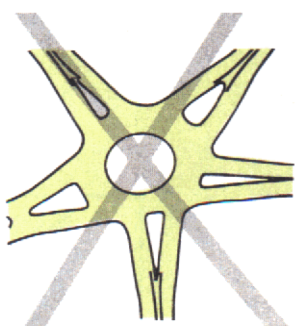
FLARED

## 3 MULTILEGGED

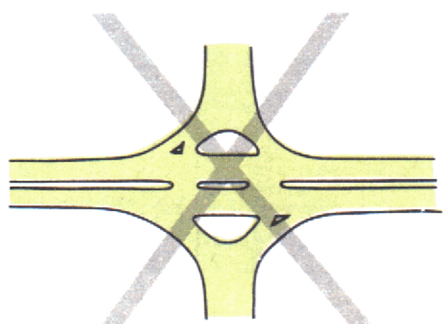
This type of intersection generally *represents a total compromise of operational requirements.* Generally, either some form of channelization and signalization should be used, or one leg of the intersection should be eliminated. However, the rotary type intersection has been used for multisided intersections with heavy turning movements and low speeds. The rotary design operation depends upon weaving, and the success of such an operation depends upon the length of the weaving section in relation to traffic volume and operating speeds. In some cases, a rotary design can be improved by routing the through traffic directly through the middle of the rotary and forcing all turns onto the rotary. Minor street and turning movements may be either stop-and-enter or signalized, depending upon the volumes of traffic to be handled.



5-LEG
NOT RECOMMENDED



ROTARY
NOT RECOMMENDED



IMPROVED ROTARY
NOT RECOMMENDED

## INTERSECTION DESIGN IMPROVEMENTS

THE TYPES OF INTERSECTION IMPROVEMENTS include a wide range of minor and major changes to intersections. For purposes of this guide, these IMPROVEMENTS have been grouped into four categories: **realignment, widening, and left- and right-turn provisions.** Not all types of improvements are included here — only the most common ones.

### DESIGN PRINCIPLES

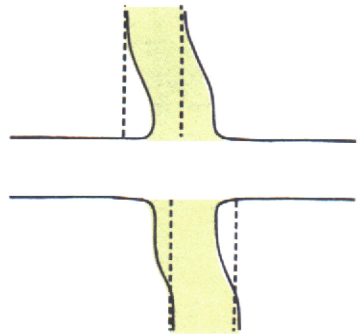
- The layout should be visible to the driver, and the moves he must or can make should be apparent. A "bird's eye" or "drawing board" view is not available for a driver to study.
- Intersection layouts should be simple. All drivers must be able to sense what to expect so that they are not required to hesitate or to decrease relative speeds while passing through an intersection.
- Intersectional design should incorporate the informational signing necessary to guide vehicles through. Problems resulting from inadequate sign position and sign message can often be avoided by good initial design of all essential components.
- The intersection should have adequate capacity for present and future traffic demands.
- The intersection should be easy to cross. Excessively skewed intersections should be avoided because of the difficulties involved in crossing them.
- Intersections should be planned to permit installation of additional control devices as traffic flow increases.

**DESIGN IMPROVEMENTS** →

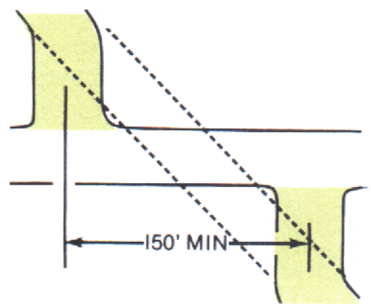
1. REALIGNMENT
2. WIDENING
3. LEFT TURN
4. RIGHT TURN

## 1 REALIGNMENT

Offset intersections — that is, intersections whose opposite halves are not in direct alignment — constitute a major traffic engineering problem. For the two halves to operate as two intersections, the offset needs to be at least 150 feet in built-up areas and at least 500 feet in outlying areas. Redesign of the intersection to match the two halves usually will reap large benefits in safety and efficiency of operation.

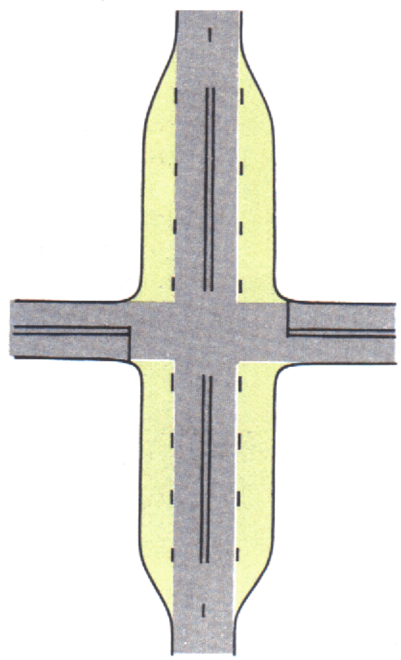


Intersections with high skew angles also are troublesome. The classical solutions to this problem are either: to realign or reduce the skew angle; or to separate the two halves of the intersection into two individual intersections by realigning the halves into T-intersections. Either of these realignments will reduce the potential for near head-on collisions that are inherent in the "before" condition. With either design, however, the tradeoff is a probable increase in the frequency of minor accidents.




## 2 WIDENING

The intersection is commonly the lowest capacity element of an arterial street system. Thus, intersectional modifications that increase the number lanes in the intersectional area can more effectively balance the capacity of the facility. Flaring is an effective intersection treatment that increases the capacity, while improving operations, of the intersection. Flaring involves increasing the width of the pavement approaching the intersection. This is accomplished usually by adding a left-turn lane or, a right-turn lane, or both, as discussed under left- and right-turn provisions. Flaring can be used also to increase the number of through lanes. However, great care must be exercised to guard against operational problems downstream. To truly be effective, the merging operation downstream requires 300 to 500 feet of taper, which usually indicates midblock lane additions as well as the intersectional improvements. For this reason, flaring usually provides space for turn lanes.



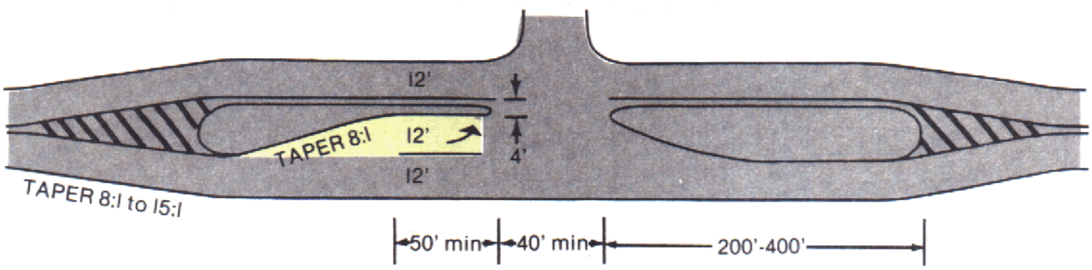
## 3 LEFT-TURN PROVISIONS

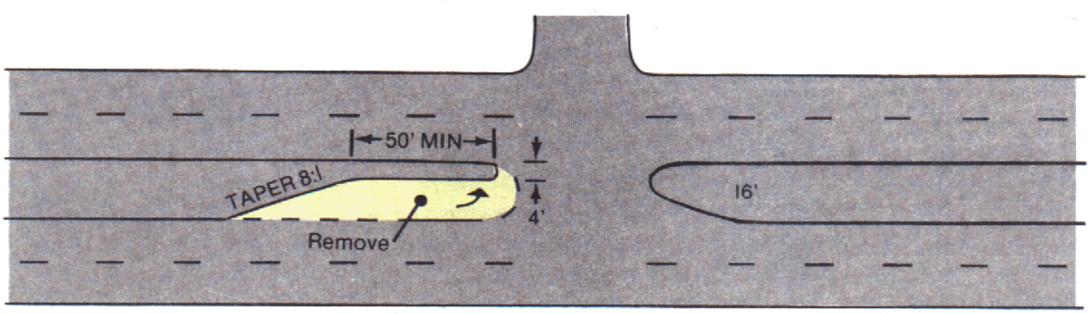
In general, A VEHICLE THAT LEAVES A MAJOR ROAD VIA A LEFT TURN *must come to a complete stop.* The **addition of left-turn lanes,** whether **by flaring or by taking space from an existing median,** can substantially increase the capacity and safety of the intersection by reducing the conflict between left-turning vehicles and through lanes.

### SINGLE TURN

For normal **two-lane facilities, the roadway at the intersection must be widened to provide the "deceleration" lane.** For a **four-lane divided road, portions of the division strip may be removed to provide a median lane.** Median widths of 20 to 25 feet are desirable for median lanes; however, widths of 16 to 18 feet are adequate.

Typical traffic volumes warranting use of this technique should exceed 8,000 vehicles per day on the major road, with 100 left-turn vehicles during the peak hour.

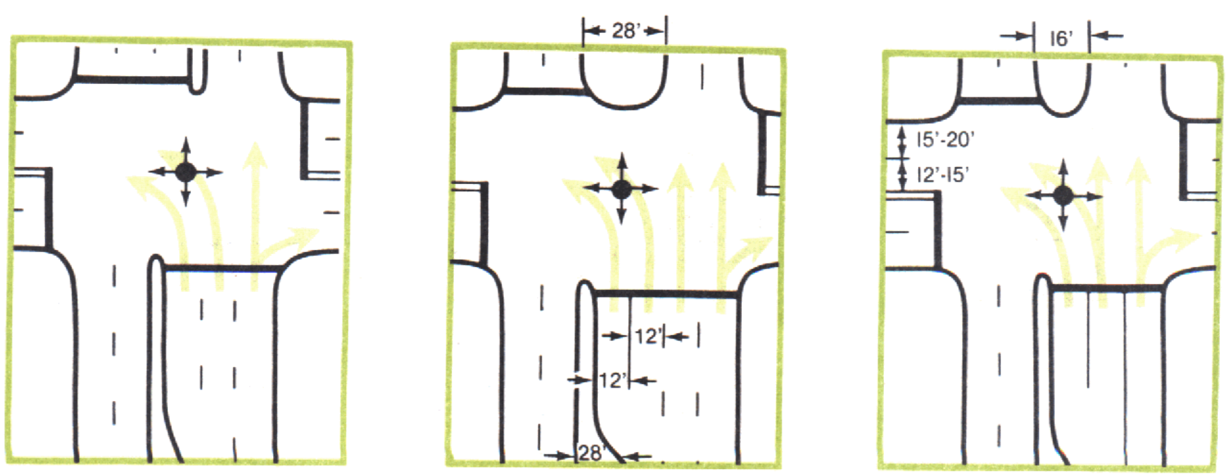


## DUAL TURN

**Where the capacity of a single left-turn lane is insufficient to accommodate the demand volume, a dual left-turning lane should be considered.** Generally, the capacity of the approach controls the capacity of the intersection; thus, to maximize the flow through an intersection and to determine the quality of service afforded, a capacity analysis is necessary. However, a 75- to 80-percent left-turn capacity increase may be predicted by adding a second left-turn lane.

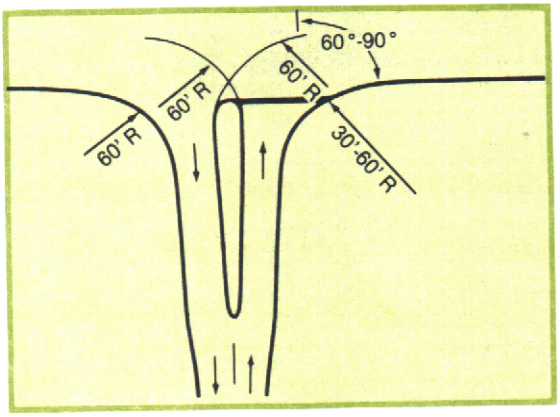
To provide a *left-turn bay* for a dual left-turn situation, it is necessary to *provide a wide continuous median or to "neck down" the lanes farther downstream.* Two through lanes in both directions and two left-turn lanes (all 12-foot lanes) would require a minimum pavement width of 76 feet, including a 4-foot median at the nose of the left-turn bay. This would then result in a 28-foot median downstream if the right-of-way were not narrowed. This width is desirable but often unavailable, especially in the more centralized areas where frequent dual left-turn lanes are needed. It is important, though, to provide a wide enough *"throat"* at intersection-entrance lanes to allow motorists to reach their lane safely and comfortably after a turning maneuver, without encroaching on another lane, the median, or curb. The operation of dual left-turn movements must be signalized, and is generally more favorable if the left turns have their own signalized phase, or if they are controlled on a leading or lagging green indication of the through phase.



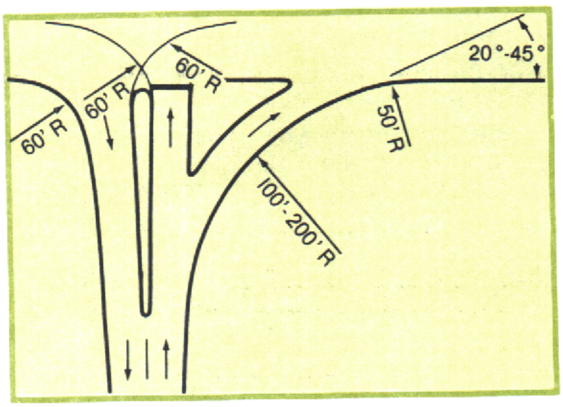
## 4 RIGHT-TURN PROVISIONS

RIGHT-TURNING MOVEMENTS may be enhanced by the **use of large corner radii, turning roadways, merging lanes, and deceleration lanes.** Generally, the technique that should be used is *related directly to the amount of traffic making the movement, the volume on the major street, and the vehicle speeds.*

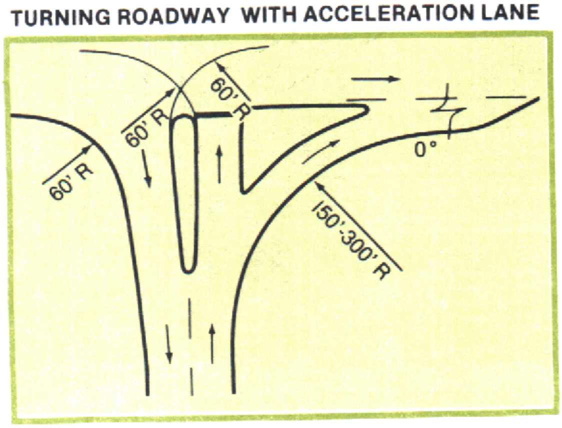
LARGE CORNER RADII




TURNING ROADWAY




TURNING ROADWAY WITH ACCELERATION LANE



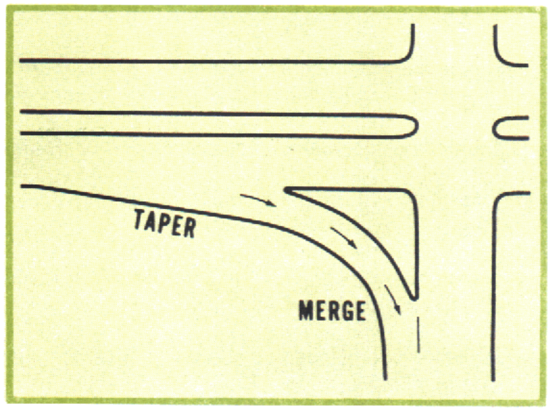

### FROM MINOR TO MAJOR ROAD

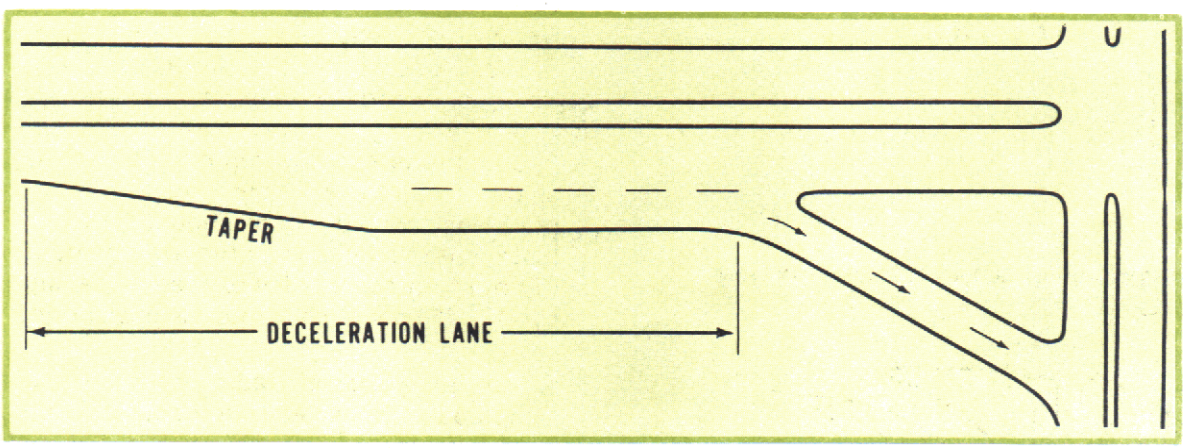
**Large corner radii** should be used where minor volumes are making a right turn and it is desirable to minimize conflict between turning vehicles and through traffic. Where there are at least 60 turning vehicles during the peak hour and 8,000 vehicles per day on the major road, **a turning roadway** may be appropriate. With this design, the angle of entry into the road should be from 20 to 45 degrees in order for the turning vehicles to enter the through lane at a moderate speed. Finally, when major street volumes exceed 8,000 vehicles per day with at least 90 right turns from the minor road during the peak hour, it may be desirable to provide for their continuous movement into the intersection. In these cases, the angle of entry onto the through lane should be zero degrees, and vehicles must be provided with an **additional lane** that extends a sufficient distance for the vehicles to weave into the main stream of traffic. In some cases, this additional lane may be added for over a thousand feet. Where turning roadways are inappropriate, intersections may be improved by adding a **special right-turn lane.** As a general guideline, consideration should be given to installing this lane when the average number of right-turning vehicles exceeds 2 per signal cycle or 120 per hour during the peak period.

When large corner radii are to be constructed, 3-centered compound curves should be used rather than large simple radii. These curves will better accommodate the turning paths of large vehicles and will reduce the pavement area required.

## FROM MAJOR ROAD TO MINOR ROAD

Vehicles leaving a major facility via a right turn **should be permitted to make their exit at a reasonable speed so that they will not be forced to slow down to a point that will hold up traffic or create unsafe conditions.** On moderate speed routes, where traffic volumes are not in excess of 8,000 vehicles per day, the right turn can be made from a "taper" and a circular curve. *The length of the taper and the radius of the curve will depend upon whether the right-turning vehicle must come to a complete stop before merging into the minor street traffic.* Where traffic volumes are at least 8,000 vehicles per day and speeds exceed 30 miles per hour, a separate deceleration lane should be formed for the turning traffic. In general, this deceleration lane and the turning radius must be related so that the vehicle can come to a complete stop, if necessary, at the entrance to the minor road.



## REFERENCES

*A Policy on Design of Urban Highways and Arterial Streets,* American Association of State Highway and Transportation Officials, Washington, DC, 1973, pp. 265-429.

Glennon, J. C., J. J. Valenta, B. A. Tharson, and J. A. Azzeh, *Technical Guidelines for the Control of Direct Access to Arterial Highways,* Report No. FHWA-RD-76-87, Federal Highway Administration, Washington, DC, 1975.

Harmelink, M. D., "Volume Warrants for Left-Turn Storage Lanes at Unsignalized Grade Intersections," *Aspects of Traffic Control Devices,* Highway Research Record No. 211, Highway Research Board, Washington, DC, 1967.

*Highway Capacity Manual,* Special Report 87, Highway Research Board, Washington, DC, 1965.

ITE Technical Council Committee 4L-M, "The Use and Effectiveness of Double Left-Turn Movements," *Traffic Engineering,* July 1975.

ITE Technical Council Committee 5N-S, "Guidelines for Driveway Design and Location," *Traffic Engineering,* February, March, and April, 1973.

Klar, Herbert J., "Designing Safe and Efficient High Volume Driveways and Intersections," *Traffic Engineering,* January 1973.

Loutzenheiser, D. W., and C. L. King, "Geometric Design," *Transportation and Traffic Engineering Handbook,* ed. John E. Baerwald, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1976, pp. 599-674.

Pignataro, Louis J., *Traffic Engineering, Theory and Practice,* Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1973, pp. 20-40.